

# **Market-Oriented Spectrum Policy Evolution in the United States: Regulatory History from Cellular to PCS**

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## Executive Summary

Spectrum regulation methodologies can be grouped into two categories. In the "*flexible methodology*," regulators strive for technology-neutral and service-neutral rules that permit markets to determine in real-time, the value of various options. In the "*homogeneity methodology*" regulators formulate market structural rules in advance of market outcomes, centered on a single technology path and the benefits of this concentration. Both methodologies have supporters in countries throughout the world.

This paper first examines the evolution of flexible spectrum policy via the regulatory history of the United States (U.S.) mobile communications market. Spanning several decades, the history begins with the cellular radio deliberations in the late 1960's. The U.S. market provides a useful case study since the spectrum regulation framework evolved from the homogeneity approach to the flexible approach, via a series of incremental policy changes.

Prior to the 1970's, spectrum was allocated to specific users, for specific purposes, and operated under technical mandates. Licenses were then assigned by lengthy administrative hearings, which became increasingly burdensome as the number of applicants increased.

Beginning in the 1970's the rapid pace of innovation in digital technologies, combined later with unanticipated interest in cellular telephony, exposed limitations of spectrum policy. Incrementally, market-oriented flexibility was introduced in technology and service rules. When combined with increased competition, innovation flourished. Under previous policy restrictions, many of those innovations could not have materialized. Spectrum license assignment also progressed toward market-oriented auctions, after the breakdowns in the comparative hearing and random-selection lottery processes experienced in the 1980's.

The final section of the paper compares the two methodologies under modern market conditions. The claimed advantages of the homogeneity methodology (economies of scale; interoperability; lack of technology fragmentation) can only be justified for an initial period, i.e. these attributes are pre-defined by the methodology. In the medium and long term, a quantitative comparison shows scale economies reach a point of diminishing return well below the levels hypothesized by the homogeneity methodology. Also, the claimed interoperability advantage of the homogeneity approach should, by extension, have led to disastrous results under the flexible approach adopted in the U.S. market. There were more competitors, air-interface technologies, spectrum bands, and incompatible license boundaries than any nation is likely to experience. Yet the U.S. market, in the medium and long term, achieved competitive nationwide interoperability and had subscriber, usage, and cost numbers that bested other nations by striking margins.

The third claimed advantage of the homogeneity methodology (i.e. avoidance of technology fragmentation) is essentially a difference in the means of facilitating innovation, rather than an advantage. The homogeneity approach focuses innovation within a single defined path, compared to multiple open paths under the flexible approach. While there may be short-term advantages to the focused approach, ultimately it constrains innovation-driven growth and impacts the breadth of new technologies available at the transition to the next generation. Longer term, the open innovation under the flexible approach permits a greater range of benefits for the marketplace, and avoids burdening future-generation market developments with regulatory predictions of technological progress.

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## 1.0 Introduction

Flexible spectrum regulation methodologies (*e.g., technology-neutral and service-neutral rules, where market outcomes determine the value of various options*), have gained favor in many countries. However, regulatory methodologies that emphasize homogeneity (*e.g., rules formulated in advance of market outcomes, centered on the avoidance of technology fragmentation, the benefits of economies of scale, and the benefits of interoperability*) also have supporters in many countries. The structural differences between these two methodologies affect the diffusion of innovation in different ways.

This paper will examine the evolution of market-oriented, flexible spectrum policy via the regulatory history of the United States (U.S.) mobile communications market. Spanning several decades, the history begins with cellular radio in the late 1960's. The U.S. market provides a useful case study since the spectrum regulation framework evolved, somewhat experimentally, from the "homogeneity approach" to the "flexible approach," via a number of incremental policy changes.

In the U.S., the Federal Communications Commission (FCC or Commission) is the regulatory agency charged with regulating radio communications (among other things). The rich history documented in the Commission's rulemaking proceedings (or dockets) dealing with radio communications issues serves as the basis for the information presented herein. A chronology of the evolution from the homogeneity approach to the flexible approach is described, along with the Commission's rationale as it trended, in a piecemeal manner, toward greater flexibility. The changing sentiment of market participants over the course of these decisions in the Commission's Dockets also is noted.

In parallel with the FCC's regulatory proceedings, the U.S. radio communications market underwent dramatic structural changes, as well as assimilating a convergence with both the computing industry and the data networking industry. These external factors had both direct and indirect impacts on the regulatory trends and technology innovations over the course of the market evolution. While these external factors were important for the introduction of digital and computing technologies, as well as packet-based networks, into the telecommunications marketplace, this paper will focus on the FCC regulatory history.

## 2.0 Analog Cellular and the FCC's First Steps (1968-1978)

The relevant U.S. regulatory history began with a proceeding in Docket No. 18262<sup>1</sup>, opened in July 1968. Reallocation and future use of spectrum in the 806-960 MHz band was the theme of the proceeding. It was the first spark of regulatory momentum toward the era of modern cellular radio communications, and that spark carried into numerous other proceedings in the years that followed. Docket No. 18262 is often referred to as "The Cellular Docket," although it actually dealt with other radio services besides cellular.

Among the key cellular-related results at the conclusion of Docket No. 18262:

- 40 MHz of spectrum was re-allocated from TV broadcasting to cellular radio, with an additional 20 MHz held in reserve for future use.
- One system would be allowed per market (the definition of "market" was still in flux), but only developmental (i.e., trial) systems were authorized until the Commission felt they had sufficient operational data to craft a complete set of rules (that task would be taken up later in Docket No. 79-318).
- Any entity would be eligible to apply for cellular authorization (not just wireline carriers, as was the case early in this proceeding).
- Operating restrictions were placed on wireline carriers to prevent anti-competitive practices (the U.S. courts would later question the effectiveness of the Commission's restrictions, but this concern would become less important with the breakup of the AT&T monopoly in 1984).

These results were the product of several iterations and much heated debate, over the course of the multi-year proceeding. Indeed, some of these rules would be modified yet again, in a subsequent docket. Officially, Docket No. 18262 lasted seven years and was replete with widely-varying proposals, speculation, opposition, and compromises before it was finally closed in July 1975. Unofficially, the cellular radio aspects of the docket extended through the court challenges to some of the interim rules (which were resolved in 1976), and finally to a stand-alone Order adopted in November 1978 (Release No. FCC 78-828), making a full 10 years of deliberations. Even then, the actual deployment of commercial cellular systems was still many years away.

The historic significance of Docket No. 18262 is more about initiating changes in regulatory mindset toward future consumer-oriented radio service than it is about the incomplete set of rules that existed when the proceeding was terminated. The proceeding took place against a backdrop where many participants (and even some Commissioners) were casting serious doubt about the alleged bright future of cellular networks, and in particular, about whether cellular mobile radio would become a consumer mass market. It was understandable, given there was no actual data, no deployment proof-points, questions about the technology readiness, questions about the costs of the networks, the equipment, and the service, as well as questions about which parties were best suited to provide the service.

The decision to finally allocate a large block of spectrum for cellular mobile communications was the most notable result from Docket No. 18262. Allocating more mobile communications spectrum had been unsupported (by the Commission) for many years. The entire U.S. mobile market existed on just a few MHz of spectrum, prior to this docket. Less noted but equally important were the expansive discussions between the Commission and the various interested parties, which "tested the waters" for new boundaries on the appropriate framework of competition, of regulations, and the role the market (as opposed to the regulators) could play in

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<sup>1</sup> Docket No. 18262 "An Inquiry Relative to the Future Use of the Frequency Band 806-960 MHz" (1968).

shaping the cellular industry structure. These discussions would carry over into other dockets in the years that followed, and a flexible regulatory framework began to take shape experimentally, piece by piece, grounded in actual market outcomes.

A notable change in the Commission's historic spectrum allocation process occurred in Docket No. 18262. In addressing spectrum allocation, the Commission (in the 1974 "2<sup>nd</sup> Report and Order") elected to allocate by system type, rather than using the more narrowly-constrained approach of allocation by service category (which had been the historic norm):

*"In the past, the Commission has treated [spectrum] requirements from a service perspective, allocating blocks of spectrum, usually on a nationwide basis, to each of the twenty or so radio service categories. This method of allocation has led to parochialism among the users and inequitable situations where spectrum shortage and abundance exist side by side in the same cities. In this docket, ... [r]ather than allocating according to user categories or services, we have chosen to allocate by system type and to allow the market to determine ultimately how much spectrum is utilized by the various types of users."*

This was one of the first of many piecemeal steps toward the "flexible methodology" of spectrum policy (i.e., increasing the flexibility of regulations governing spectrum licenses). As market data over the years showed the various steps toward "flexible methodology" were viable, it became the Commission's standard methodology. However, the transition to the flexible methodology (from the homogeneity methodology that had been the Commission's standard practice for many years) was more like a gradual displacement of several regulatory components, as opposed to a wholesale switch.

Near the official end of Docket No. 18262, the Commission (in a March 1975 Memorandum Opinion and Order) raised the issue of developing definitive technical standards for the cellular systems. These standards would be mandated (i.e., the "homogeneity methodology"), which was common practice at the time:

*"Although cellular systems research has been developed to advanced stages by AT&T, considerable additional work must be done before standards may be prescribed for such systems on a regular basis, especially standards which would assure compatibility nationally. Therefore, as we announced [previously], only developmental cellular systems would be authorized. Following that (developmental system) program, we will adopt standards to which all systems, existing and new, will be required to conform."*

In November 1978, the Commission issued an Order, announcing its intent to adopt definitive technical standards and regulations for cellular systems by January 1980. This would be handled in a new docket focused on cellular radio (Docket No. 79-318). The Commission also presented a status report on the cellular developmental systems, noting the progress on the two authorized systems – one in Chicago, via AT&T (Illinois Bell), and the other in Baltimore/Washington, via American Radio Telephone Service (ARTS) in partnership with Motorola.

As a "sidebar" to Docket No. 18262, in September 1973, the Commission published (in a Memorandum Opinion and Order) a letter it received from technologists in a separate government

agency known as the Office of Telecommunications Policy (OTP).<sup>2</sup> This OTP letter was one of the earliest outlines of market-oriented technology-neutral and service-neutral spectrum policy principles for commercial mobile radio services. By way of introduction, OTP stated that the large spectrum block at issue in Docket No. 18262 enabled “*the adoption of new and improved procedures for allocating and using the radio spectrum.*” The letter elaborated on that comment at great length, outlining OTP’s recommended spectrum policy goals and objectives, for national communications policy. Some selected passages from that OTP letter are presented below.

#### Excerpts from OTP’s Spectrum Policy Recommendations to the Commission:

Regarding market-based flexibility versus regulator-driven market structures, OTP states:

*"A major issue posed in this proceeding is whether the increased availability of mobile communications services is best achieved by a regulatory commitment to a monopoly system premised upon a particular technology, or by the creation of a diverse competitive environment."*

*"[We believe] the needs of mobile communications users can best be met by an approach which enables customers themselves to determine, through market mechanisms, the most efficient and cost-effective use of the spectrum resource."*

OTP comments on a nationwide network under technology mandates:

*"Although a nationwide, standardized mobile telephone system, dependent upon a particular technology, might well [materialize], no need has been adequately demonstrated"*

*The mobile telephone service market does not appear to exhibit strong natural monopoly features, and there is no conclusive information as to whether there are economies of scale sufficiently substantial to justify a policy commitment to a single system or a particular technology. In a period of rapid technological change, there are significant risks attendant to a commitment of a substantial portion of spectrum to a particular technology (however innovative it may presently appear) for the provision of mobile telephone service on a nationwide basis. Such a commitment could unduly inhibit further technological development and impede the growth of mobile telephone services."*

However, OTP also noted that spectrum policy must consider the nationwide outcome as a viable market-driven result. They recommended the broader policy environment must include a flexible regulatory framework considerate of that outcome, but not inherently biased toward it.

On the topic of “services,” OTP suggested a market-oriented policy, which they believed “...*should result in more diverse service offerings at competitive prices and vigorous technological innovation to improve and expand those services.*” They go on to state, “*The Commission’s allocation [of spectrum] should allow the provision of all types of service (mobile telephone, dispatch, paging, etc.) on a competitive basis by all potential entrants.*”

On the question of spectrum efficiency, OTP suggested that it was important for the Commission to “*encourage industry experimentation in areas such as channel spacing, through experimental assignments and other means, in order to further improve spectrum efficiency.*” “*If past technical innovation through such experimentation is any guide, even the most optimistic projections of market demand for mobile communications may be accommodated in less spectrum than has been specified in some of the cellular system proposals.*”

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<sup>2</sup> The Office of Telecommunications Policy was established by the Executive branch of the U.S. government in 1970 to advise the Administration on communications policy issues. In 1978, a successor organization known as the National Telecommunications and Information Administration (NTIA) was formed under the Department of Commerce.

To summarize the state of regulatory mindset at the opening of Docket No. 18262, the homogeneity methodology was the dominant policy approach in the majority of Commission dockets dealing with radio spectrum up to that point. It was also dominant over the course of Docket No. 18262, in particular with the Commission's intent to mandate the use of the Commission's approved standard for mobile and base station equipment. However, the Commission did introduce certain aspects of the flexibility methodology by designing in multiple competitors per market, and by deviating from the traditional approach of allocating spectrum to specific user classes, and instead allocating by system type (which would allow multiple user classes within their competitive framework). This flexibility would be carried forward to virtually every commercial spectrum-related proceeding that followed.

### **3.0 Completing the Analog Cellular Regulatory Structure and Market Introduction (1979-1983)**

In November 1979, the Commission opened Docket No. 79-318<sup>3</sup>, to finalize the rules leading to the first commercial cellular deployments in late 1983. As noted in the prior section, the "homogeneity methodology" remained the prevailing spectrum policy approach at this time. However, the flexible approach was beginning to displace certain aspects of policy that were showing evidence of constraining effects on innovation and growth. These will be described in more detail through the remainder of the paper. The key decisions reached by the time the proceeding was terminated in February 1982 were:

- 1) The adoption of a mandatory technical standard for nationwide compatibility between mobile and base stations (i.e., a product of the homogeneity approach).
- 2) Permitting two licensees in each of 734 cellular market areas<sup>4</sup>, where each licensee would get 20 MHz of spectrum (i.e., flexibility intended to increase competition compared to earlier allocations). Shortly after the proceeding was terminated, the multi-year, multi-phase assignment of the nearly 1500 separate cellular licenses began.

The decision to allow two competitors per market was an attempt to "*[balance] the benefits of economies of scale against the benefits of competition.*" The Commission stated that "*such an approach, while not providing the most competitive market structure, would provide some competitive advantages, including the fostering of different [network architecture] approaches, diversity of service options, and some degree of price competition which otherwise would not be present.*"

Consistent with the "homogeneity methodology," the Commission mandated certain technical requirements, including the Electronic Industry Association's (EIA) cellular mobile and base station compatibility standard (which was based on the developmental systems deployed by AT&T and by American Radio Telephone Service and its partner, Motorola). Informally, this came to be known as the AMPS (Advanced Mobile Phone System) standard. Officially, it was known as OST Bulletin No. 53.<sup>5</sup>

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<sup>3</sup> Docket No. 79-318 "An Inquiry Into the Use of the Bands 825-845 MHz and 870-890 MHz for Cellular Communications Systems" (1979).

<sup>4</sup> There were 734 cellular market areas defined nationwide, with two licenses awarded per market area. Of the 734 market areas, 428 were designated as rural markets, and 306 as urban markets. The rural markets were known by the acronym RSA (Rural Statistical Area) and the urban markets by the acronym MSA (Metropolitan Statistical Area). The licenses for the rural cellular markets were assigned after the urban markets.

<sup>5</sup> Initial cellular systems were required to conform to a technical compatibility standard (OST Bulletin No. 53) that was designed to ensure that all mobile phones work anywhere that a cellular system operates. This standard contributed to the creation of a nationwide



Cellular licenses would be assigned in 20 MHz partitions identified as Block A (for non-wireline carriers, i.e. any cellular carrier applicant that does not operate a wireline telephone network) and Block B (for wireline carriers<sup>6</sup>, primarily AT&T at the time). After a two year period, the Commission planned to remove the distinction between the A and B blocks for specific classes of carriers. This would allow any block which was still unused after two years to be open to any entity.

The first round of cellular license applications, for the 30 largest markets (MSA<sup>7</sup> 1-30), was accepted in June 1982. The first (wireline) license grants went to the AMPS Corporation (a subsidiary of AT&T, set up specifically for the operation of nationwide cellular service). After the effective date of the AT&T divestiture<sup>8</sup> in January 1984, the wireline (B Block) licenses issued to the AMPS Corporation were divided among the original seven Regional Bell Operating Companies (RBOCs).

Subsequent rounds of license groups (e.g., MSA 31-60 in round 2; MSA 61-90 in round 3) were opened to application at intervals of four to five months. Competing applications submitted for the non-wireline A Block licenses increased to unanticipated levels, with each application voluminous in technical and operational detail. The FCC was faced with such a massive and time-consuming administrative burden in resolving all the comparative hearings<sup>9</sup> for each license that, in May 1984, the Commission decided all the licenses beyond the first 30 MSA's would instead be assigned by a random-selection lottery process. While this reduced the time to assign licenses, it created a "gold rush" applications process.

The tales of the cellular license assignment debacle are told in colorful detail elsewhere (e.g., George Calhoun's book "Digital Cellular Radio," pages 120-135). For the purposes of this paper, it is sufficient to say there was unanimous opinion it was a process that should never be duplicated again; one that must be overhauled. Hordes of "spectrum speculators" having no qualifications as cellular network operators bought their "lottery tickets" at modest cost, and distorted market outcomes by squeezing out viable competitors that weren't lucky enough to win licenses. As Calhoun notes, *"The licensing disaster—that is the only word for it—[removed] from the field many of the stronger potential competitors (particularly the major non-wireline carriers) who might have had the staying power and the long-term vision to work through the transition."*

Even after dropping the lengthy comparative hearing approach after the first 30 licenses, and using the lottery approach thereafter, the assignment process took many years. The vast majority of the MSA and RSA licenses were assigned over the course of a lengthy multi-phase process lasting from 1982 to 1989. The sheer number of applications for the 428 RSA licenses (over

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service. The full title is "Cellular System Mobile Station -- Land Station Compatibility Specification," OST Bulletin No. 53. The OST -- the Commission's Office of Science and Technology -- has since been renamed the Office of Engineering and Technology.

<sup>6</sup> The AT&T Bell System consisted of 22 wholly-owned Bell Operating Companies (BOCs), collectively having about 80 percent of the U.S. local telephone market. The remainder of nationwide telephone network coverage was handled by a collection of smaller telephone companies, plus two telephone companies in which AT&T held a minority interest. The term "wireline carriers" refers to this entire collection of companies which operate wireline telephone service.

<sup>7</sup> See Note 4 for a description of MSA.

<sup>8</sup> AT&T agreed to divest its local exchange service operating companies as part of the settlement of the U.S. Department of Justice antitrust suit. The settlement was finalized in January 1982. Effective January 1, 1984, AT&T's local operations were split into seven independent Regional Holding Companies (RHCs), also known as Regional Bell Operating Companies (RBOCs) or "Baby Bells."

<sup>9</sup> Comparative hearings were an administrative process that the Commission used to select from competing applications for licenses. The process required each party to present a detailed case, demonstrating why they were the best suited applicant for the license. The hearings were often lengthy, complex, and sometimes led to protracted litigation by losing parties. Competing applicants sometimes had so few relevant differences that the resulting choice was characterized by some as a random selection.

300,000 applications were submitted in total, with no real constraints on who could apply) shows the speculative mania surrounding the lottery process.

The first commercial system (operated via a subsidiary of the Regional Bell Operating Company Ameritech) became operational in October 1983<sup>10</sup> in Chicago, and the second system in Baltimore/Washington followed in December 1983. Twenty-five wireline systems in the B block and nine systems in the non-wireline A block were operational by the end of 1984. By the end of 1985, there were 80 wireline systems compared to 15 non-wireline systems in operation. The non-wireline systems closed the gap by 1986 and, by the end of that year, there were two competing systems in most of the top 90 MSA markets.

While the multi-year cellular license assignment process did ultimately resolve, it was not without unexpected costs and delays. A better approach was desired by all. Several Congressional and Commission policy debates concerning spectrum license assignment regimes would take place in the ensuing decade, leading ultimately to the auctioning of spectrum licenses. This will be described later, in Section 9.0.

#### **4.0 Changing Markets, Changing Policies: Overhauling the FCC's Technical Regulations (1983-1984)**

The next Commission Docket in the chronology of market-oriented spectrum policy evolution was Docket No. 83-114<sup>11</sup>, opened in April 1983. The Commission described their intent “...*our principal objective...is to eliminate unnecessary technical regulations [in existing spectrum allocations] and thereby create an environment that encourages innovation and avoids unnecessary and costly rulemaking.*”

This proceeding highlighted more generally the Commission's recognition that changing telecommunications market structures and rapid technology innovations called for a matching level of flexibility in the spectrum policy framework. The flexible approach described in the Report and Order in Docket No. 83-114 soon would have an impact on future regulatory proceedings dealing with the cellular market, the PCS market, and virtually all the commercial mobile radio markets that followed. In describing the backdrop for this proceeding, the Commission noted four trends:

- 1) Technical regulations and standards—while they may have been useful or even necessary to bring a new service or system to the marketplace—may no longer be necessary once that service or system has matured.
- 2) The pace of technology evolution may have reached a level where rigid regulatory constraints impede the introduction of improved technologies and services.
- 3) The industry is generally more competitive now than in the past, which lessens some of the market-structure concerns which have led to government involvement in the standards setting process.

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<sup>10</sup> While the AT&T divestiture was not complete until January 1984, the first steps began in 1982. Ameritech was incorporated in 1983 and was one of seven Regional Holding Companies after divestiture. Its mobile subsidiary (Ameritech Mobile Communications) operated the cellular systems.

<sup>11</sup> Docket No. 83-114 “Re-Examination of Technical Regulations” (1983).

4) There may be less restrictive regulatory approaches, which preserve essential rules, but reduce constraints on technological innovation.

The Commission recalled that the rationale behind many existing regulations came from the traditional regulatory concepts that were applied to broadcast services, dating back decades. It explained that the level of diversity in competition, technology, and service may now (in 1983) be sufficient to warrant the elimination or revision of certain technical regulations, and this will vary depending on the particular market as well as types of service. The primary risk in maintaining technical regulations, it noted, is in being too constraining, which might unnecessarily restrict implementation of technologies or services not envisioned when the regulation was adopted.

In November 1984, the Commission terminated the proceeding in Docket No. 83-114 with the adoption of a Report and Order describing the policy areas where the Commission believed a more flexible regulatory approach was appropriate. It is noteworthy that several of the Commission's conclusions aligned in large measure with the OTP (Office of Technology Policy) spectrum policy recommendations from 1973, highlighted earlier in section 2.0 of this paper.

On the topic of interoperability requirements (a form of technical compatibility mandate), the Commission characterized it as more important for certain types of service and/or equipment, making it difficult to define a single, unified policy. For example, with certain maritime and aeronautical services, there are several factors – such as national security, emergency preparedness, and/or safety of life and property – that justify interoperability mandates. Additionally, there are instances where interoperability is mandated by treaty or law. In those cases, any technical flexibility that frustrates interoperability is unacceptable.

While acknowledging that there are cases where interoperability is of sufficient importance to warrant retention of existing interoperability regulations, the Commission explained that there are many other cases where market forces will achieve interoperability in the absence of direct regulatory constraint, e.g., through industry standards and/or signal or protocol conversion mechanisms. Concluding that there would continue to be special cases requiring special treatment, the Commission expressed its general tendency to favor marketplace solutions absent those special cases:

*“The Commission does find reason to reach different conclusions in different cases, when considering whether to adopt technical regulations or to rely on the marketplace for purposes of assuring interoperability. Increasingly, however, we have recognized both the potential frustration of innovation and the cost, both direct and indirect, of employing our regulatory process to set such standards and have generally forborne from adopting detailed technical regulation except in cases in which the uncertainties of reliance on the marketplace clearly could not be tolerated.”*

There are also cases where existing interoperability regulations may no longer be needed, e.g., after some period of market development has entrenched them. The Commission noted that while interoperability mandates can be useful as an initial condition for brand new markets involving large public participation (e.g., cellular phone service), they would seek greater flexibility when: (1) the market is sufficiently well established that initially-mandated interoperability will be maintained as voluntary standards and (2) the installed base of equipment is sufficient to give manufacturers and service providers the incentive to make any new changes compatible with the original equipment. In these non-safety cases, they would also consider alternatives to mandatory standards, such as an endorsement of an industry-developed standard, rather than requiring it.

On interference control, the Commission noted the basic objective would be to increase flexibility in system design as much as possible, without increasing potential interference beyond what existed under present technical rules. It noted that the present structure of tightly-defined emissions tailored to a single technology has had a negative impact on innovation. For unoccupied spectrum, it suggested even greater flexibility may be possible, which could give licensees valuable options in introducing innovative technology and avoid the need for Commission action and delays when new technologies are proposed.

On spectrum efficiency requirements (i.e., how much spectrum is used to produce a given output), the Commission noted such requirements were often used to justify standards on modulation type and frequency tolerance. It goes on to explain the technology-neutral policy position that would guide them going forward:

*“[E]xplicit regulation of the spectrum efficiency of radio systems is not required where the following two conditions are both met: (1) licensees have an incentive to operate efficiently and (2) licensees are given the flexibility to choose the technical details of their system. Where significant flexibility is not possible...the preferred type of regulation is one that specifies the required spectrum efficiency (e.g., bits/second/Hertz) as opposed to a particular technology.”*

On regulating technical quality, the Commission considered most telecommunications equipment and service markets had become sufficiently disciplined by the pressures of competition and consumer choice, such that low levels of quality would not be accepted by the marketplace.

In summary, the Commission elected to pursue greater flexibility and reliance on the marketplace in future proceedings, in the areas of interoperability requirements, interference control, spectrum efficiency, and technical quality standards. While this docket was an important milestone in summarizing a collection of policy principles that would guide future Commission rulemaking proceedings, there would be additional aspects of flexible, market-oriented spectrum policy addressed in future dockets, described in later sections.

## **5.0 The Surprising Demand for Cellular Leads to Early Release of the Spectrum Held in Reserve (1985-1986)**

In response to a petition filed by Ameritech Mobile Communications, Docket No. 84-1231<sup>12</sup> was opened in January 1985 to address pleas for additional cellular spectrum. After a little over a year of commercial cellular deployments, strong market demand meant carriers already saw signs of reaching capacity, thus justifying their request to release the spectrum held in reserve.

In early 1985, the cellular market served primarily the business community, but was expected, as costs continued to decline, to be increasingly used by consumers. Most of the 30 largest markets had operational systems, and license applications were being processed for the next 90 markets. By the time of the Report and Order in this docket (in July 1986), wireline carriers were operating systems in most of the top 120 markets. Non-wireline carriers were being purchased by wireline carriers (e.g., the seven RBOCs) in some geographic areas once the courts found these

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<sup>12</sup> Docket No. 84-1231 “Additional Frequency Allocation for Cellular Systems” (1984).

transactions permissible. Thus, there was now the potential for two wireline carriers to operate the two cellular systems permitted in each of the 734 cellular market areas.

Shortly after the first wireline carrier acquisition of a non-wireline license in January 1985, McCaw Cellular (a non-wireline carrier) began aggressively acquiring non-wireline licenses. McCaw was the only major cellular player that built its coverage footprint entirely from non-wireline licenses. Due to the ongoing lawsuit regarding the legality of wireline companies purchasing non-wireline licenses, prices for the non-wireline licenses remained low.<sup>13</sup> After the acquisition binge, McCaw became the largest cellular operator by 1990 and, by 1992, its network covered 65 million, or slightly over 25 percent of the U.S. population.<sup>14</sup> In 1994, AT&T acquired McCaw Cellular. The \$17.5 billion purchase price (including McCaw's debt) made the deal the second largest take-over in U.S. history at the time.

With respect to the pleas for additional cellular spectrum, the Commission cited various studies that concluded cellular demand would exceed capacity in the top ten market areas within a few years. The Commission noted that ideally the capacity problems could be solved by more advanced, spectrum-efficient cellular technology in the existing allocation, but it acknowledged that the industry was not expecting these new technologies to be market-ready until the 1990s. That would be too late to alleviate near-term congestion in major markets. Thus, the Commission agreed that additional spectrum from the reserve allocation should be granted to cellular radio.

Ten megahertz of additional spectrum was allocated to cellular service, dividing it equally between the non-wireline and wireline spectrum blocks (i.e., each block would now have a total allocation of 25 MHz, compared to 20 MHz prior to this docket). The additional spectrum was made available to existing and future cellular licensees without further application, but its use was optional. That allowed carriers in smaller markets that were not close to capacity limits to hold off on costly network upgrades. The mandated technical compatibility standard (OST Bulletin No. 53, known informally as the AMPS standard) remained in force, but the Commission recognized that it would need to consult with the cellular industry to make the appropriate modifications to the standard in order to deal with the larger spectrum block size.

## **6.0 The FCC Proposes the First Fully-Flexible “General Purpose Mobile Service Allocation” (1985-1986)**

The Commission also used Docket No. 84-1231 to propose a “General Purpose Allocation” of new spectrum. This would prove to be a significant “regulatory trial balloon” for the flexible allocation methodology, and would eventually be employed as part of the PCS spectrum (although PCS spectrum was not yet contemplated at the time of this docket). While it would be a narrow bandwidth allocation (2 MHz compared to the 25 MHz cellular allocations), it would still be suitable for a number of different services in smaller or rural markets. The Commission described it as follows:

*“[The allocation] would be highly flexible in defining the utilization of the spectrum. The only stipulation would be that the spectrum be used for mobile services, but details regarding service type and system design would be made by individual licensees.”*

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<sup>13</sup> James Murray et.al., *Wireless Nation*, Perseus Publishing, 2001

<sup>14</sup> The second largest cellular coverage footprint in 1992 was GTE with coverage of 53.6 million; the third largest was Bell South with 44.6 million; the fourth largest was Southwestern Bell with 36.2 million; and the fifth largest was PacTel with 36.5 million (from Thomas Hazlett, “*Is Federal Preemption Efficient in Cellular Phone Regulation*,” Dec. 2003).

*“This approach [to] place greater reliance upon market forces to apportion spectrum among the various mobile services might be in the public interest.”*

Industry (in 1985) was by no means unanimous in their support of this flexible approach by the Commission. Opposing comments raised the greater interference potential, spectrum inefficiency, and nationwide equipment compatibility and scale issues (i.e., the hallmark issues for the homogeneity approach). Supportive comments emphasized that the real-time marketplace adjustments via the flexible approach drive ongoing innovation in technologies and services (i.e., the hallmark issues for the flexible approach).

Neither side of the issue had much real-world evidence, since there was not yet a mass-market proof point of a flexible allocation to draw from. However, there were indications from smaller wireless markets where the flexible approach had been applied, that the marketplace had successfully navigated the issues raised in this proceeding by opponents. The Commission listed the example of the flexible approach used for the SMR (Specialized Mobile Radio) market, where multi-system compatibility was achieved, and the example of common carrier microwave services, where channel widths and modulation types are not mandated by the Commission, but through frequency coordination among carriers, interference is rare. In any event, the Commission opted to move ahead with their proposal for the flexible General Purpose Allocation:

*“We find considerable merit to the proposition that permitting market forces to determine how to apportion the spectrum among various mobile services is in the public interest.”*

*“We are not persuaded that user flexibility will lead to significant technical problems. We concur with the views of those commenters who declare that economic rewards will provide users with a powerful incentive to make intensive use of their assignments.”*

*“...the creation of a service that gives users a greater say in how their assignments are used provides a fair and efficient solution to the complex allocation problems we face, both now and in the future. Accordingly, we are allocating 2 megahertz (901-902 MHz and 940-941 MHz) to a General Purpose Mobile Service. This new mobile service will be accessible to all [mobile uses].”*

The Commission stated that it would take up the details of the technical rules and license assignments to complete this flexible “General Purpose Mobile Service” in a future proceeding. It would take about four years, but Narrowband PCS experimental licenses would be granted for this spectrum in 1990, and the first docket dealing with the PCS spectrum would be opened the same year. Ultimately, this spectrum would be auctioned for Narrowband PCS.

The principles of this highly flexible approach would carry forward to the PCS proceedings (to be discussed in a later section). The broadband PCS allocation would be structured with similar regulatory flexibility as the narrowband PCS allocation. However, at the conclusion of Docket No 84-1231, there remained a fair degree of skepticism toward the flexible methodology, among industry participants in the proceedings. Those concerns would lessen over time, as more discussions on the flexible approach took place in several future dockets, and more market data demonstrating the value of the flexible methodology was gathered.

## **7.0 Putting the Flexible Approach into Practice: Retrofitting the Cellular Rules (1987-1988)**

Docket No. 87-390<sup>15</sup> was opened in September 1987, not quite four years after the first commercial cellular deployment became operational, and a little over one year since the last remaining cellular spectrum held in reserve was handed over to cellular operators. Customer demand had exceeded all predictions, especially in larger markets. Cellular market data indicated that some cellular systems would again be pushing their capacity limits within the next few years (even with the additional spectrum that was released from the reserve). Since no additional spectrum allocation was on the horizon, cellular operators would have to rely on new technology advances to resolve capacity issues going forward. There was a problem though: the original technology mandate<sup>16</sup> governing the cellular spectrum did not permit the implementation of new technologies.

In light of this problem, and given that new technology and equipment development can take several years, the Commission elected to take action ahead of time. As the Commission explained in the Notice of Proposed Rulemaking for this docket, the mandatory standards served a useful purpose in providing a stable environment for the initial growth of a brand new cellular market. However, the strict requirements imposed by the standards were now an impediment to the introduction of the more spectrum-efficient technologies needed to accommodate the anticipated growth. This mirrored the Commission's flexible policy position noted earlier, in Section 5.0 describing the results of Docket No. 83-114.

In October 1988, after gathering inputs from interested parties, the Commission decided to allow "technology flexibility" by cellular licensees. This was a major milestone in the progression of flexible regulations. The new rules would allow cellular operators to elect to introduce new cellular technologies in a portion of their existing spectrum allocation, on a secondary, non-interfering basis, and as rapidly (or gradually) as the demand in each market called for. Cellular operators were required to continue to provide conventional cellular service (the "primary" service), in a portion of their spectrum. New technologies would be considered "secondary" to conventional cellular (meaning any interference to the primary service must be corrected, or the secondary service must be discontinued). There were also requirements for technical analysis and coordination with adjacent cellular operations (for interference mitigation purposes), when new technologies were deployed.

The basis of this technology flexibility decision was that certain requirements from the original cellular rules such as channeling plans, emission types, and modulation types were inhibiting the introduction of advanced cellular technology (e.g., modulation techniques other than the mandatory form of FM were prohibited). Consistent with the flexible approach, the Commission declined to impose a mandatory technology standard for new cellular technologies, and would take this same position in all commercial spectrum allocations going forward. The Commission felt there was a clear distinction between using the "homogeneity" approach for a brand new market with unknown demand, versus growing an established vibrant market. In addition, the Commission noted that the Telecommunications Industry Association (TIA) Standards Committee had already begun work on technical compatibility standards for the next generation

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<sup>15</sup> Docket #87-390 "Amendment of the Commission's Rules to Permit Liberalization of Technology and Auxiliary Service Offerings in the Domestic Public Cellular Radio Telecommunications Service"

<sup>16</sup> Recall that cellular service was initiated under the "homogeneity methodology" of spectrum policy. Cellular had (to this point) been governed by mandatory technical and compatibility standards (known by the shorthand "the AMPS standard," the official nomenclature was OST Bulletin No. 53).

of cellular systems, with several advanced cellular technologies under consideration. The Commission encouraged this development, stating that, *“Industry is in a better position to evaluate the technical advantages and disadvantages of the various advanced cellular technologies.”*

Noting that adoption of the initial analog cellular standard took several years via the regulatory process, the Commission stated: *“We believe that the transition to new cellular technologies will be encouraged and made easier by granting cellular operators the liberty to implement them without the delay involved in a Commission rule making. We anticipate that the industry will find ways to achieve compatibility between [systems].”*

Some industry participants were reluctant to embrace the flexible approach, with potential interference from the new technologies as one of their concerns. The Commission felt its requirement for up-front engineering analysis, to test interference scenarios, would suffice in the majority of cases. In the more difficult cases, interference issues would be handled through the frequency coordination process (which was already defined under FCC rules). The Commission explained that cellular operators have already demonstrated cooperation in avoiding interference, and possessed all the necessary technical and operational resources to manage interference between systems. In addition, the fact that new technologies would have “secondary service” status meant they would be required to cease operation of the new technologies if there were cases where interference issues could not be resolved.

Equipment compatibility and maintaining conventional cellular service were two other areas where the Commission had to address the appropriate level of requirements versus flexibility. Specifically, the Commission had to decide whether to mandate a certain minimum amount of spectrum that remained dedicated to conventional cellular, and whether to mandate equipment cross-compatibility between conventional cellular and new technologies (for example, dual-mode handsets). The Commission's decisions on these two issues are described below.

First, the Commission noted that the amount of spectrum required for maintaining conventional service will vary substantially from one system to the next, as well as varying over time as demand changes. It declined to set a minimum requirement for maintaining conventional service, believing the cellular licensees are in the best position to determine the proper mix for their markets. It goes on to state that the large and growing subscriber base, together with the large investments in the network, makes it highly unlikely that cellular operators would neglect their existing systems or disenfranchise customers.

On the second issue, the Commission declined to mandate any dual-mode requirements for mobile or base station equipment. The Commission noted that a cellular operator choosing to implement new cellular technology would need to deploy base stations that provided conventional cellular service as well as advanced cellular service, but the details of that deployment were best left to the cellular operators. Further, it noted that mobile equipment manufacturers would be able to design and market customer equipment that operates in dual mode (i.e., digital and analog cellular) or any of the single-modes. This would allow the customers to decide what modality best meets their varying usage habits.

The decision to let the market determine the appropriate combinations and capabilities of dual mode equipment had important ramifications for future innovations in multi-mode devices worldwide. Dual mode (and later, tri and quad mode) equipment had many challenging design and packaging trade-offs. The devices have been refined and improved through successive



generations<sup>17</sup> without the encumbrances of mandates set early in the process, and without the need to pursue a lengthy rulemaking process for each new generation of multi-mode devices. The unencumbered dual-mode equipment developments for the U.S. market helped lay the technology and manufacturing groundwork for multi-mode devices in subsequent generations of cellular and PCS networks, in devices that operate worldwide, and in devices with additional modes derived from the data networking and computing industries such as WiFi and Bluetooth.<sup>18</sup>

## 8.0 Status Report for the Cellular Marketplace after the First Five Years

Before discussing the Personal Communications Services (PCS) market and regulatory developments, a brief status report on the state of the cellular market at the time the Commission issued the Report and Order in Docket No. 87-390 (i.e., late 1988) is presented below.

### Cellular Market Status: The First Five Years (1983-1988)

#### Overview

Commercial cellular deployment in the U.S. had just celebrated its five year anniversary in late 1988. Cellular service and mobile equipment remained costly, but significant reductions had taken place since the first deployment launched in late 1983. Prices were still well above the thresholds needed for mass consumer adoption, but there wasn't sufficient network capacity to support mass consumer markets until the rule changes in Docket No. 87-390 allowed more spectrum-efficient digital technologies.

#### Customer Equipment Trends

The first handheld portable phones had entered the marketplace, but they were still greatly outnumbered by the much less expensive car-mounted units. Hand-portables were about 6 percent of U.S. sales in 1988. Car phones sold for around \$3,000 initially, but had dropped to the \$700 average price range by 1988. Hand-portables began shipping in volume around 1986 (average price around \$2,500, roughly twice the price of car phones), and had dropped to an average of about \$1,200 by 1988. (See Figure 1 below.)

#### Subscriber Growth and Service Cost

Subscribers had grown to a half-million by mid-1986, and topped two million by the end of 1988. The average monthly bill in 1988 was \$100, and this would turn out to be the historic peak. By 1987, annual industry revenues topped \$1 billion for the first time.

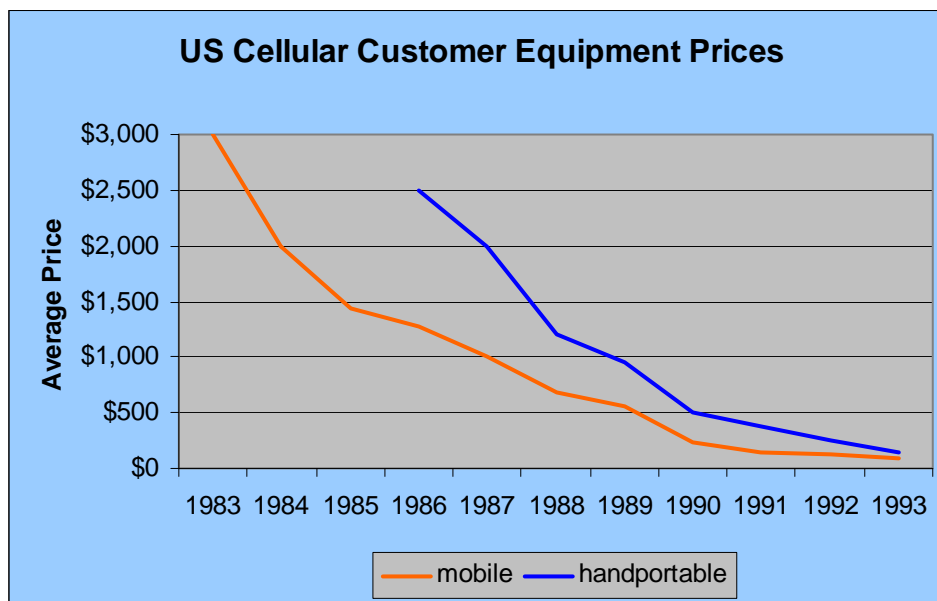
#### Outside the U.S.

GSM efforts began in 1982. It would be 1992 before the first large-scale commercial deployments. Analog cellular based on the "AMPS standard" (or derivatives of it such as TACS) had spread from North America to South America, Asia, and Europe. Even as digital standards spread worldwide, AMPS and its derivatives still had 62 percent of worldwide market share in December 1996.

[Sources: CTIA Semi-annual reports; FCC Annual CMRS reports; Garry Garrard, "Cellular Communications: Worldwide Market Development" Artech House 1998; Rudi Bekkers and Jan Smits, "Mobile Telecommunications: Standards, Regulation, and Applications," Artech House 1999.]

<sup>17</sup> The first dual-mode handsets (i.e. AMPS + TDMA or AMPS + CDMA) came to market in the early 1990's. They were not only larger than their single-mode analog counterparts, they also cost more than twice as much. Less than ten percent of US subscribers had dual-mode handsets in 1994. By 2000, more than half (60%) of worldwide handset sales were dual-mode, and estimates were for that number to increase to 90% by 2003. See Harald Gruber, "The Economics of Mobile Telecommunications," Cambridge University Press, 2005 and "Cellular/PCS Handsets," Cahners In-Stat Group, Report No CE9906WL, May 1999.

<sup>18</sup> In 2007, 26.8 million dual-mode WiFi handsets shipped, and that number is expected to reach nearly 150 million handsets by 2010. Also in 2007, 54.8 percent of digital mobile phone shipments were Bluetooth-equipped. See "Impact of Devices on a Mobile Broadband Universe," In-Stat, Report No. IN0803956WBB, March 2008, and "Bluetooth 2008: New Standards Signify an Increasingly Complex Market," In-Stat, Report No. IN0804097MI, August 2008.



**Figure 1.** Customer equipment price trends in the U.S. cellular market.

(Note: "Mobile" refers to vehicle-mounted equipment, e.g. car phones.) Source; Garry Garrard, "Cellular Communications: Worldwide Market Developments," Artech House, 1998, p46.

## 9.0 Establishing Personal Communications Services (PCS) (1989-1996)

Personal Communications Services (PCS) were the "next great hope" for bringing new innovative technologies and services to the marketplace, following the momentum created by cellular radio. In the nearly seven years that elapsed between the first cellular deployments in late 1983 and the first PCS regulatory proceeding in 1990, the mobile communications technology and service landscape had undergone dramatic change. One of the most significant factors was the rapid advance of digital integrated circuit technology, which in turn made possible the complex digital signal processing techniques that are at the core of wireless digital communications. As an FCC Commissioner summarized it retrospectively<sup>19</sup>:

*"Digital technology has liberated information. Information of all types (voice, pictures, video and text) can be encoded, transmitted and decoded by tiny microprocessors with an efficiency never before imagined. Information is no longer constrained to any particular means of distribution and can be manipulated in an unlimited number of ways. Because of the infinite flexibility of digital technology, traditional market barriers also have begun to crumble." "On the horizon are entirely new players using innovative technologies to enter the communications market...."*

The first PCS Docket No. 90-314<sup>20</sup> was opened in June 1990, in response to several petitions filed in 1989, seeking a spectrum allocation for new communications services. The Commission

<sup>19</sup> FCC Commissioner Michael Powell speech, Legg Mason Investor Workshop, March 13, 1998; [Powell 1998]

<sup>20</sup> Docket #90-314 Amendment of the Commission's Rules to Establish New Personal Communications Services (1990)

stated that it would broadly define PCS as a family of services including voice, data, imaging, and other new services. Its intent was to encourage a variety of competing firms with their own visions of PCS to bid for various combinations of licenses and to provide a diverse array of new services.

At the time this docket was opened, most of the usable spectrum below 3 GHz had already been allocated to specific services, and assigned to specific licensees. Therefore, the Commission needed to identify spectrum that could be shared between a new service and an existing service, or that could be reallocated to a new service once the incumbent licensees relocated to other spectrum.

The Commission identified a swath of spectrum in the 1850-2200 MHz range, to be used for PCS and other emerging technologies. Portions of this spectrum were already occupied by fixed microwave services. The Commission developed rules for band sharing between PCS licensees and existing incumbent fixed microwave facilities, and/or for negotiated relocation of those fixed microwave facilities to other spectrum above 3 GHz. Permitting the PCS license winners to negotiate a mutually acceptable “buy out” of the microwave incumbents (i.e. pay for their relocation to new spectrum) was important for timely deployment. Clearing the spectrum for a new use (i.e. PCS) was also expected to have greater value for a larger range of consumers.

During the PCS proceedings, the Commission referred back to Docket No. 87-390 (which liberalized the technical rules for the cellular spectrum, in 1988; see Section 7.0) as the model for its PCS goals:

*"Our experience suggests that we should adopt a PCS regulatory structure that allows similar flexibility in implementing new services and technologies. In sum, we are proposing policies for PCS licensing that respond to the needs of the marketplace."*

The Commission recognized that many PCS concepts and technologies were still being developed, and a technical framework that would permit significant flexibility in the design and implementation of PCS systems, devices, and services was appropriate:

*"We believe that this flexible approach... will encourage the development of the broadest range of PCS services and devices; foster the most economic and efficient use of the spectrum; and ensure that existing services and PCS operations are protected from interference."*

The Commission then proceeded to address the specifics of the band plan and licensing scheme for PCS. A decade prior, when the Commission defined the band plan for cellular telephone service, it decided to divide the U.S. geographically into 734 metropolitan and rural service areas (MSAs and RSAs), for licensing purposes (see Section 3.0). In each service area, two licenses were issued. However, the effective operating service areas of the resulting cellular systems became much larger. By the early 1990s, a number of large cellular firms had acquired additional licenses in aftermarket transactions and each served substantial portions of the U.S. population (although not necessarily with contiguous service areas).

High transaction costs were incurred in aggregating these hundreds of licenses into large coverage areas (estimated at over \$100 million in 1991 alone). In addition, the administrative burden in initially assigning the large number of licenses delayed the rollout of cellular, perhaps by several years. Because of these factors, the Commission declined to use those cellular

MSA/RSA boundaries when defining PCS. They were deemed too small for the efficient provision of regional or nationwide mobile service.

Instead, the Commission elected to begin with larger service area boundaries for the PCS licenses. The same operational savings that drove cellular toward larger service areas were expected to exist for PCS as well. Indeed, the Commission intended for at least a portion of the PCS spectrum to compete directly with the large cellular systems. This change was expected to minimize the need for costly post-auction transactions, and the associated delays. Large PCS service areas were also expected:

- to facilitate regional and nationwide roaming and interoperability;
- to reduce the cost of interference coordination between PCS licensees;
- to simplify the coordination of technical standards.

The new, larger service area definitions were known as Major Trading Areas (MTAs)<sup>21</sup>, with 51 non-overlapping MTAs nationwide. These were intended to facilitate the assembly of large PCS coverage footprints. However, the Commission was also required by Congress to facilitate participation in PCS by a wide variety of small and medium sized entities. Broader participation was expected to produce a greater diversity and degree of technical and service innovation in the fledgling PCS market than would be expected from a few large firms.

To meet that requirement, the Commission would also allocate some PCS spectrum using the smaller Basic Trading Areas (BTAs) as the geographic boundaries for licenses. There are 493 BTAs nationwide, and their smaller geographic size compared to MTAs was expected to be more appropriate for smaller entities that were interested primarily in serving their local area.

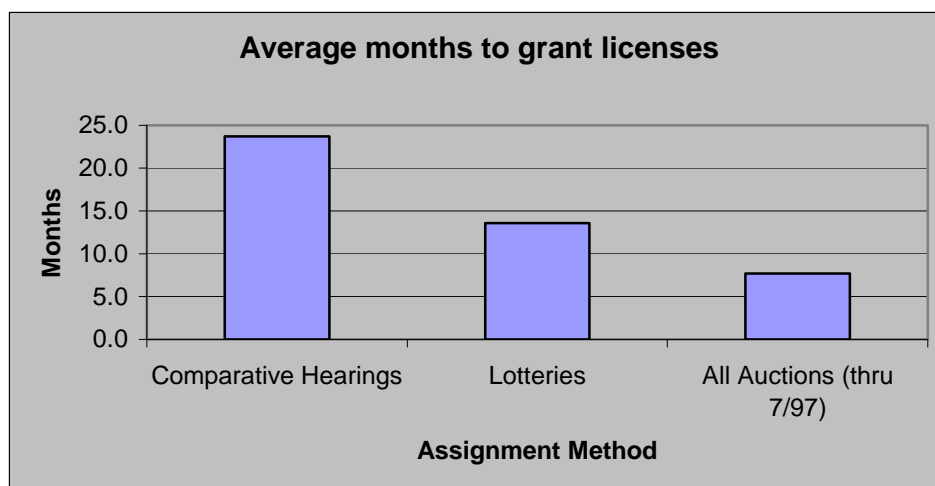
The Commission's first band plan proposal was greeted with numerous objections. After consideration of industry comments and suggestions, the final band plan consisted of three 30 MHz licenses (Blocks A, B, and C) and three 10 MHz licenses (Blocks D, E, and F), all within the 1850-1990 MHz band. The A and B Blocks would be licensed based on the larger Major Trading Areas (MTAs) and the C, D, E, and F Blocks would be licensed based on the smaller Basic Trading Areas (BTAs). The variety in block sizes (which in turn could be aggregated to form other block sizes) and in license geographic boundaries was expected to have broad appeal. The Commission had a reasonable picture of the wide-ranging interest they could expect for PCS licenses, since they had issued experimental/temporary licenses to nearly 100 different companies, as a proving ground for new PCS services and technologies in advance of Commission rules.

Another important development, and an integral component of market-oriented spectrum policy, was the approval by Congress in August 1993, to authorize the Commission for the first time to select licensees by competitive bidding (i.e., spectrum license auctions). Congress also restricted the cases where the Commission could use lotteries to assign licenses. In 1997 the legislation was updated to require the use of competitive bidding in most cases, and terminated the Commission's authority to use lotteries. Recall (from Section 3.0) the Commission's use of comparative hearings and spectrum lotteries to assign cellular licenses was inefficient and controversial. After numerous Congressional and Commission hearings, the Commission could finally conduct the first spectrum license auction. In the Commission's 1997 Report to Congress on auctions<sup>22</sup> it noted that auctions resulted in less delay (see figure 2), lower administrative costs, and more efficient assignments when contrasted with comparative hearings and lotteries.

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<sup>21</sup> MTA and BTA boundaries are defined in the 1992 Rand McNally Commercial Atlas & Marketing Guide.

<sup>22</sup> "The FCC Report to Congress on Spectrum Auctions," Document No. FCC 97-353, Sept. 30, 1997



**Figure 2.** Average duration in granting licenses for the various assignment methods.

Note that auction averages above include the time to file and process bidder applications, not just the auction duration. Also note the average for lotteries does not include delays for the aftermarket transactions which transferred licenses from speculators to those intending to deploy networks. Source: "The FCC Report to Congress on Spectrum Auctions," Document No. FCC 97-353, Sept. 30, 1997

The first FCC auction took place in July 1994, resulting in the assignment of 10 Narrowband PCS licensees, each with nationwide scope. To this point in the paper, all the PCS discussions have referred to the so-called Broadband PCS in the 1850-1990 MHz range. Narrowband PCS inherited the Commission's 900 MHz "General Purpose Allocation" made in Docket No. 84-1231 (see Section 6.0). However, that docket left the final details of the operating rules and license assignment to a later proceeding. Those final Narrowband PCS details would be set by the Commission during the same time frame as Broadband PCS.

While the bandwidth of these Narrowband PCS licenses is too small for the most demanding wireless services, their significance for the purposes of this paper is in the Commission's highly-flexible allocation approach, relying on market forces to determine the technologies and services, rather than Commission mandate. It was one of the earliest examples of the flexible allocation approach for new spectrum. Most of the principles of today's flexible allocation approach remain unchanged from their descriptions in Docket No. 84-1231, which was closed in 1986.

The auction for Broadband PCS licenses began in late 1994, with the auction of the 30 MHz A and B blocks. The auction was completed in early 1995 after about three months. The C block auction began in late 1995, lasting about 4.5 months, and the 10 MHz D, E, and F block auctions began in late 1996, also lasting about 4.5 months. Since the Commission declined to mandate the deployment technology, PCS operators chose between three industry standard technologies: one was a form of digital TDMA adapted from the cellular variant, one was a form of CDMA, also adapted from the cellular variant, and the third was a form of GSM that was known by the shorthand PCS1900, adapted from a European variant.

PCS operators had different motivations for their technology choice. For example, PCS license winners that also had 800 MHz cellular licenses (if they had begun converting those licenses to digital technology), would sometimes elect an up-banded version of the same digital technology for their PCS licenses. Conversely, new PCS entrants with no existing compatibility issues had fewer constraints on their technology choice. Several new entrants in the MTA licenses (including the very first operational PCS network in late 1995) went with the GSM variant known as PCS1900. By late 1996, most MTA licensees had made their technology selection. Once

deployment was complete (which would take several years), the population coverage for the three industry-standard technologies would each reach significant scale: 243 million for CDMA, 140 million for PCS 1900, and 114 million for TDMA.<sup>23</sup>

### **Sidebar: Nextel Finds Opportunity in the FCC's Flexible Regulations**

Nextel was founded in 1987 as Fleet Call Inc., by former FCC lawyer Morgan O'Brien. O'Brien saw opportunity in consolidating thousands of small Specialized Mobile Radio (SMR) licenses to bring increased operational efficiency and new services, including digital cellular telephony. SMR was a fragmented "mom and pop" industry, and the service was used primarily for fleet dispatch, e.g. taxicabs and delivery truck fleets.

In contrast to the larger cellular licenses, each Fleet Call/Nextel SMR license was only 25 kHz wide, and the license area was a 70 mile circle around a central transmitter station. An incredible 42,000 licenses were acquired in two dimensions: aggregating bandwidth, and aggregating coverage area. Ultimately this mosaic of thousands of tiny SMR licenses would give Nextel a nationwide coverage area and sufficient bandwidth to challenge the cellular incumbents.

By 2002, Nextel was the 5<sup>th</sup> largest cellular carrier, covering a population of 230 million. Against all odds, and faced with a massive license aggregation and negotiation task that made even the small geographic size of cellular RSA and MSA licenses look huge by comparison, Nextel was able to assemble a nationwide, interoperable network using the digital technology of its choice.

The path to success involved two key aspects of the Commission's flexible spectrum policy. First, the Commission's rules allowing the transfer of licenses via the secondary marketplace allowed Nextel to buy out existing license holders, since they placed a higher value on the potential use of the licenses than existing holders. Second was the Commission's technology and service rule flexibility, allowing the 1970s-era analog trunked radio technology of SMR to be replaced with modern digital cellular technology. The Commission's SMR rules did not explicitly allow the digital technology so, in 1990, Fleet Call filed a request with the FCC to permit digital cellular operations. Incumbent cellular carriers naturally opposed the request, but the Commission in February 1991 found that its SMR rules already permitted wide-area digital cellular operation and unanimously granted Fleet Call's request. The only stipulation was the rules did require the provision of dispatch service (later to be known as Nextel Direct Connect) in a portion of the spectrum. In March 1993, after a string of merger and acquisitions to complete the nationwide footprint, Fleet Call announced its name change to Nextel.

[Sources: Diana Furchtgott-Roth (editor), *"Overcoming Barriers to Entrepreneurship in the United States,"* Lexington Books, March 2008; Thomas W. Hazlett, *"Is Federal Preemption Efficient in Cellular Phone Regulation?"* In *Federal Communications Law Journal*, Vol 56, No 1, December 2003; Morgan O'Brien comments in transcript of FCC Secondary Market Forum, Washington DC, May 31, 2000; Sprint/Nextel Application for Transfer of Control, Valente/West Declaration, Attachment 2.]

<sup>23</sup> Garry Garrard, *Cellular communications: Worldwide Market Development*, p343, Artech House, 1998.

## 10.0 Conclusions and Comparisons of the Two Regulatory Methodologies

As discussed in the document, the U.S. moved from the homogeneity methodology to the flexible methodology, by taking a number of incremental steps between the late 1960's and the 1990's. The gradual and piecemeal transition was due in large part to the lack of market proof-points justifying the regulatory changes in advance. As market data confirming the benefits of each action developed, successive steps by the Commission had growing support from market participants. The regulatory changes to increase flexibility involved both the allocation and the assignment practices for spectrum. Highlights of the Commission's actions are summarized below:

### Spectrum Allocation: Highlights from the U.S. Market Evolution:

Prior to the 1970's, U.S. spectrum allocations were targeted for specific users (e.g. police radio allocations, fleet dispatch allocations), under dozens of separate categories. The 1968 cellular docket took a first step, allocating instead by system type, which could be adopted by many categories of users. This had the benefit of opening the allocation to a larger number of entrants. However, a single-technology mandate was maintained, which was common practice at the time. As demand for cellular services exceeded all predictions, and as digital technology fueled numerous innovations to expand capacity and capabilities, the technology mandate became an impediment to introducing those new technologies.

In the 1980's, the Commission relaxed the rules, allowing the cellular spectrum to be retrofitted with new technologies, while maintaining the legacy analog cellular service. Beneficial innovations in multi-mode cellular equipment followed, and in turn those innovations have fueled worldwide developments in multi-mode radios well beyond the original scope of telecom networks. By the 1990's, the Commission allocated a new band of spectrum for PCS, which allowed full flexibility for license holders to choose technologies and services.

This led to beneficial marketplace competition for TDMA and CDMA technology variations. If technology mandates had persisted through the 1990's, there would have been little motivation for the extensive CDMA development efforts. In turn the transition to 3<sup>rd</sup>-Generation technology would not have had the market proof-points which eased the decision to shift to CDMA technology, rather than TDMA. Thus, a key benefit of the flexible approach is in allowing multiple market innovations to proceed in parallel.

### Spectrum Assignment: Highlights from the U.S. Market Evolution:

Prior to the 1980's, U.S. spectrum licenses were assigned through a lengthy administrative process known as comparative hearings. As commercial and mass-market mobile services sparked adoption by the marketplace, interest in acquiring spectrum licenses also increased. The high level of interest overwhelmed the Commission's administrative process, causing long delays in assigning licenses, and criticisms of the fairness of the process. Spectrum lotteries were then introduced, in order to reduce the delays. However, the lottery process had numerous shortcomings and criticisms in spite of speeding up the process. The next step in the spectrum assignment evolution was spectrum license auctions.

The auction process has proven highly successful, with the FCC holding more than 70 auctions in the 14 years since the process was authorized in the 1990's. The auction process also led to larger, contiguous license areas, as well as the ability for bidders to aggregate licenses during the auction, to meet the scale of their business plan. Allowing secondary market transactions (spectrum

license swaps and acquisitions between private parties) has also led to significant success in assembling wireless coverage footprints. One of the most notable success stories is Nextel's nationwide cellular network, assembled from thousands of small licenses that were not originally envisioned for cellular networks. The Commission's flexible rules permitted Nextel's ambitious plans, which led to one of the nation's largest networks.

#### Comparing the Two Regulatory Methodologies:

The primary benefits claimed by supporters of the flexible methodology include:

- 1). Technology-neutral and service-neutral rules allow markets to determine outcomes based on real-time information.
- 2). Multiple paths of innovation (implied by technology and service neutrality) promote a greater breadth of future opportunities.
- 3). Economies-of-scale and interoperability are achieved by the market, even with more than one technology path.

The primary benefits claimed by supporters of the homogeneity methodology include:

- 1). Avoidance of technology fragmentation (i.e. multiple technology paths) via some form of single technology mandate.
- 2). Economies of scale (as a by-product of a single mandated technology)
- 3). Interoperability and compatibility (also a by-product of a single mandated technology)

At the root of the homogeneity methodology is a single technology mandated by regulators. In accordance with the three claims, the primary benefits would not be adequately fulfilled without this mandate. Therefore, the comparison between the homogeneity approach and the flexible approach hinges on the comparative analysis of the technology mandate. The analysis is not static; the cumulative costs and benefits change over time, when comparing the two approaches.

Consider a hypothetical comparison where country "H" (under the homogeneity approach) and country "F" (under the flexible approach) both begin a wireless service deployment at the same time (all else being equal).<sup>24</sup> Conceptually, there would be an initial period where the homogeneity approach for country "H" ranks superior in achieving interoperability, scale economies, and lack of technology fragmentation. This is simply a consequence of the multiple technology paths taken by country "F," which inherently divides the initial measures across the technology paths, compared to the homogeneity approach of country "H." This scenario is likely the basis for the assertion that interoperability and economies-of-scale under the homogeneity approach ranks superior to the flexible approach.

However, the initial relative comparison of the methodologies is not destined by fate or by fundamental principles to hold over time. In fact, the U.S. experience with the flexible approach demonstrates that market participants will achieve interoperability and will achieve scale economies, even in the presence of multiple technology paths. The enduring difference between the homogeneity approach and the flexible approach is then in technology fragmentation, i.e. multiple technology paths. Consequently, the key question becomes, is technology fragmentation an asset or a liability in modern markets? Before exploring that question, it is useful to compare interoperability and economies-of-scale across the two approaches, to examine whether there are meaningful differences in magnitude.

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<sup>24</sup>While there is no real market comparison meeting the hypothetical constraints, it provides a useful reduction in the number of uncontrolled variables, and allows the fundamental expectations of the two approaches to be critically examined.



#### Comparing Economies of Scale:

The benefits of economies of scale do not increase without bound. They reach a point of diminishing return at a fraction of the scale implied by the single ubiquitous market of the homogeneity approach. One of the most substantial examples of economies-of-scale benefits is in the cost trends of semiconductor components. In the case of cellular telephony, the implication of the homogeneity approach is that the semiconductor costs of a GSM handset (due to the huge worldwide volume) should be significantly below that of a US-TDMA handset. Functionally, the two handsets both utilize TDMA technologies, and contain similar semiconductor components and complexity. However the US-TDMA market scale is significantly less. In the comparison data below, a timeframe around 1999 was used because both GSM and US-TDMA had reached significant adoption, but by no means their eventual totals.

	1998	1999	2000
GSM	\$45.56	\$41.76	\$37.65
US-TDMA	\$43.78	\$40.60	\$37.06
US-CDMA	\$69.75	\$65.37	\$60.79
Analog	\$25.94	\$23.73	\$21.77

**Table 1.**<sup>25</sup> Average semiconductor wholesale cost (US\$) per handset, by air interface technology

	1998	1999	2000
GSM	124.2	191.4	273.7
US-TDMA	18.4	37.0	60.3
US-CDMA	17.3	37.9	66.0
Analog	80.8	83.5	81.0

**Table 2.**<sup>26</sup> Worldwide subscribers, by air interface technology (millions)

The data shows the semiconductor costs for a US-TDMA handset and a GSM handset (see Table 1) were approximately the same, and maintained that insignificant differential for an extended period, despite the huge (and growing) difference in subscriber scale (see Table 2) between the two technologies. This indicates that the actual benefits of economies of scale reach the point of diminishing return well below the level implied as an advantage via the single-market homogeneity approach.

CDMA handset costs are also included for comparison purposes, since CDMA handsets were inherently more costly than TDMA-based technologies due to the complexity of the circuitry. The success of CDMA technology in the (worldwide) marketplace demonstrates another factor of interest, namely that markets do not shun a technology simply because it is inherently more costly. The minimization of the absolute cost of the handset was judged by market participants as a secondary factor, compared to the technology capabilities of CDMA. This choice by the marketplace would not even have been possible if the entire market had been operating under a single-technology mandate. Perhaps more importantly, CDMA technologies could not have supplanted TDMA in the transition to 3<sup>rd</sup>-Generation technologies, without a flexible regulatory

<sup>25</sup> "Cellular/PCS Handsets," Cahners In-Stat Group, Report No CE9906WL, May 1999.

<sup>26</sup> "Cellular/PCS Handsets," Cahners In-Stat Group, Report No CE9906WL, May 1999.

framework permitting CDMA technologies to prove their value in segments of the marketplace not operating under the homogeneity approach. Among those other markets are the U.S. PCS and digital cellular markets (see Sections 9.0 and 7.0).

In summary, the economies-of-scale comparison between the two methodologies does not yield a meaningful advantage because both methodologies reach sufficient scale to maximize the benefit. Scale in excess of that threshold shows minimal benefit. In the absence of such advantage, regulatory mandates on technology, for the expressed purpose of maximizing market scale economies, are not justifiable by market data.

#### Comparing Compatibility and Wide-Area (e.g. Nationwide) Interoperability:

A single air-interface technology mandate does not necessarily guarantee compatibility and wide-area interoperability. Analog cellular in the U.S. was originally regulated under an air-interface technology mandate and a compatibility standard mandate (see Section 3.0), but not an interoperability standard mandate. The marketplace of cellular operators agreed to an interoperability standard within a few years of the first commercial cellular deployments, but it was not mandated by regulation. During those first few years, cellular network deployment was just getting underway, and was far from the nationwide coverage achieved in later years. The early lack of nationwide interoperability is of less significance when the network itself is sparsely deployed.

The interoperability standard governs, among other things, the type and format of data exchanged when a subscriber roams outside their home network. In the U.S. market, this standard has evolved through several generations of added capabilities, and this evolution was made easier by the fact that a lengthy regulatory rulemaking was not required to implement the improvements. The important point is the marketplace of cellular providers was motivated to develop and adopt the interoperability standard.

When technology flexibility was adopted by the Commission for the 800MHz cellular spectrum (to allow new technologies; see Section 7.0), and when full technology flexibility was adopted for PCS spectrum (see section 9.0), the interoperability standard was quickly updated by the cellular industry in each case. Dual-mode handsets (analog and digital) were also important in extending interoperability until newer technologies had been deployed nationwide. By 2000, there were six nationwide wireless carriers<sup>27</sup> in the U.S., utilizing a mix of five different air-interface technologies (AMPS, US-TDMA, GSM, CDMA, and iDEN), across three different allocations of spectrum (cellular 800MHz, PCS 1900MHz, and SMR 8/900MHz).<sup>28</sup> This was achieved entirely by the marketplace, without regulatory mandates.

Thus, the only potential comparative benefit for the homogeneity approach when it comes to interoperability is in the short-term period after initial deployments. This temporary advantage could only be the case if the industry (under a flexible approach) has not yet developed the interoperability standards. For the majority of the useful technology life of the network, the two regulatory approaches can achieve equal wide-area interoperability and compatibility outcomes. For future generations of technology, market-developed interoperability standards via the flexible methodology would likely have a timeliness advantage over standards under regulatory control.

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<sup>27</sup> The six nationwide carriers were: Verizon, Cingular, AT&T, Sprint, Nextel, T-Mobile

<sup>28</sup> Thomas W. Hazlett, "Is Federal Preemption Efficient in Cellular Phone Regulation?" In Federal Communications Law Journal, Vol 56, No 1, December 2003; [Hazlett 2003].

The U.S. market has the largest number of nationwide competitors (see Table 3), the largest number of different technologies deployed, and the largest number of license areas to aggregate<sup>29</sup> toward nationwide coverage. Even under these extremes of conditions, nationwide interoperable and compatible networks were achieved many times over, by the marketplace, without regulatory intervention. The example of Nextel's SMR efforts (see sidebar from Section 9.0) is an even more striking example of motivated market participants reaching nationwide interoperability.

Number of Competitive Nationwide Wireless Networks (Jan 2001)	
6	United States
5	Japan, South Korea, Netherlands
4	Canada, Denmark, Germany, U.K.
3	Australia, Austria, Belgium, Finland, France, Greece, Ireland, Italy, Mexico, Poland, Portugal, Spain, Sweden, Switzerland
2	Czech Republic, Hungary, Iceland, Luxembourg, New Zealand, Norway, Turkey

**Table 3**<sup>30</sup>. Number of national networks across world regions

In summary, as with economies of scale, wide-area interoperability and compatibility can be achieved under both methodologies. Absent an advantage for the homogeneity approach (which relies on regulators predicting market outcomes in advance), the real-time market adjustments inherent in the flexible approach implies better-informed decision making, and more optimal timing of those decisions.

#### Comparing Technology Fragmentation:

Lacking any meaningful evidence that favors the homogeneity approach for economies of scale or interoperability, the remaining comparison is whether technology fragmentation (i.e. multiple technology paths) is an asset or a liability in modern markets. The flexibility methodology can indeed lead to markets that are fragmented by technology. The underlying premise implied by the homogeneity approach is that fragmentation is a sign of a dysfunctional market, or is an undesired outcome to be avoided. However, modern markets often do decide that "winner take all" is not the most productive long-term outcome. Multiple technology paths can simultaneously produce substantial and on-going innovations, which can even be shared for mutual benefit across those paths.

In today's dynamic markets where continuous innovation is a driving force for continued growth, the longer-term value in maintaining parallel technology paths (each producing ongoing innovations) is very often the choice markets make (compared to the short-term consistency benefits of choosing a single path).<sup>31</sup> A single technology path, bounded by regulation, is

<sup>29</sup> The United States selected 734 cellular franchise areas, 51 PCS-A and PCS-B franchise areas, and 493 PCS-C, -D, -E, and -F franchise areas. No other Organization for Economic Co-Operation and Development ("OECD") country had more than the eleven franchise areas used by Canada. The great majority of countries issue national licenses for mobile wireless on the presumption that wide area networks are efficient. Excerpted from [Hazlett 2003].

<sup>30</sup> Thomas W. Hazlett, "Is Federal Preemption Efficient in Cellular Phone Regulation?" In Federal Communications Law Journal, Vol 56, No 1, December 2003.

<sup>31</sup> The computing and data communications industries are good examples of markets electing multiple parallel paths of technology and innovation, and allowing them to persist for long periods. There continues to be multiple computer operating systems, hardware and graphics platforms, internet browsers, internet search engines, IP voice protocols, and many more. There is every sign the market

inherently more limited in the breadth of future innovations it can produce, compared to multiple unencumbered paths. The extent of future innovations can also be magnified by the competition across the technologies, as exemplified by the CDMA and TDMA battles which drove wireless telephony platforms toward multimedia ecosystems supporting voice, video, and data.

In conclusion, two of the three claimed advantages of the homogeneity methodology (economies of scale and interoperability/compatibility) do not bear out as meaningful advantages over the flexibility methodology. The third claimed advantage (i.e. avoidance of technology fragmentation) is the only attribute of the homogeneity methodology with a lasting difference compared to the flexibility methodology. The difference amounts to different expectations in facilitating innovation: a single, confined path compared to multiple open paths. While there may be certain short-term advantages to focusing innovation within a set of boundaries set by regulators, ultimately it limits the range of possibilities for innovators. The longer term advantage of allowing innovations to flow without artificial regulatory boundaries would appear to maximize the benefits of innovations to the marketplace.

In closing, the following quotation from a speech by former FCC Chairman Powell<sup>32</sup> aptly summarizes the rationale favoring a market-oriented flexible regulatory approach:

“...we must acknowledge that we cannot accurately predict what technologies and services will ultimately prevail in the marketplace. Regulatory history is filled with examples of failed predications about technological progress.” “The truth of unpredictability counsels restraint. We should not dare to pick technology winners or losers, whether consciously or unconsciously. Assuredly, we will be wrong more often than right.”

“Markets are far superior devices for controlling prices, spurring innovation, enhancing quality and producing consumer choice than are central planning models. It is futile for bureaucratic regulatory agencies to attempt to keep pace with the demands of high technology markets.”

“[P]olicymakers must work to avoid (1) slowing the pace of innovation in technology and service offerings and (2) inadvertently picking or conferring advantage to a particular technology or service. If regulation is necessary at all, it should be consistent with competitive markets and sufficiently flexible to accommodate unknowable future technological advances.”

Table 4 below includes current data (year-end 2007) showing that the U.S. transition from the homogeneity approach to today’s fully flexible approach has resulted in favorable market outcomes:

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(which is free of regulatory intervention) continues to value the flow of innovations from these parallel paths more than the market values the avoidance of technology fragmentation. At any time, the market is free to terminate any underperforming paths that are no longer producing value.

<sup>32</sup> FCC Commissioner Michael Powell speech Legg Mason Investor Workshop, March 13, 1998;

Global Wireless Marketplace, through 2007										
	Subscribers		Avg monthly Minutes of Use		Avg cost per Minute		Top Two Carriers % of Total Market		# of Carriers w/ >1 Million Subscribers	
	numeric	graphical	numeric	graphical	numeric	graphical	numeric	graphical	numeric	graphical
USA	243.3m	-----	823	-----	\$0.04	-----	51.7%	-----	10	-----
Japan	103m	----	140	--	\$0.25	-	78.6%	----	4	----
Germany	91.1m	----	101	-	\$0.21	--	72.4%	-----	4	----
U.K.	71.4m	---	168	--	\$0.20	---	49.6%	-----	5	-----
France	50.2m	--	258	---	\$0.17	----	82.5%	----	3	----
Italy	85.2m	----	134	--	\$0.19	---	73.4%	-----	4	----
Canada	19.1m	-	429	-----	\$0.10	-----	68.3%	-----	3	----
Spain	48.1m	--	163	--	\$0.23	-	77.5%	----	3	----
S.Korea	42m	--	321	-----	\$0.11	-----	82.4%	----	3	----
Mexico	62m	---	144	--	\$0.11	-----	90.7%	-	4	----

**Table 4.** 2007 Global Wireless Data. Source: CTIA, State of the Global Wireless Marketplace, Written *ex parte* communication, filed in WT Docket 07-71, Jan 8, 2008.

## 11.0 References and Additional Reading

### 11.1 FCC Orders, Documents, Reports

#### Docket No. 18262

In the Matter of An Inquiry Relative to the Future Use of the Frequency Band 806-960 MHz; and Amendment of Parts 2, 18, 21, 73, 74, 89, 91 and 93 of the Rules Relative to Operations in the Land Mobile Service Between 806 and 960 MHz

1. Notice of Inquiry and Notice of Proposed Rulemaking, 14 FCC 2d 311, Adopted July 17, 1968
2. First Report and Order and Second Notice of Inquiry, 19 *Rad. Reg. 2d (P & F)* 1663, Adopted May 20, 1970
3. Second Memorandum Opinion and Order, 31 *FCC.2d* 50, Adopted July 28, 1971
4. Memorandum Opinion and Order, 42 *FCC.2d* 957, Adopted September 19, 1973
5. Second Report and Order, 46 *FCC.2d* 752, Adopted May 1, 1974
6. Memorandum Opinion and Order, 47 *FCC.2d* 731, Adopted June 19, 1974
7. Memorandum Opinion and Order, 51 *FCC.2d* 945, Adopted March 19, 1975
8. Memorandum Opinion and Order, 55 *FCC.2d* 771, Adopted July 16, 1975

Related to Docket No 18262:

9. NATIONAL ASSOCIATION OF REGULATORY UTILITY COMMISSIONERS, Petitioner, v. FEDERAL COMMUNICATIONS COMMISSION;

NATIONAL ASSOCIATION OF RADIOTELEPHONE SYSTEMS, Petitioner, v. FEDERAL COMMUNICATIONS COMMISSION;  
ILLINOIS ASSOCIATION OF RADIO-TELEPHONE SYSTEMS, INC., Petitioner, v. FEDERAL COMMUNICATIONS COMMISSION;  
RAM BROADCASTING COMPANY, Petitioner, v. FEDERAL COMMUNICATIONS COMMISSION;  
Nos. 74-1555, 74-1585, 74-1659, 74-1696; UNITED STATES COURT OF APPEALS FOR THE DISTRICT OF COLUMBIA CIRCUIT, *173 U.S. App. D.C. 413*; *525 F.2d 630*; *35 Rad. Reg. 2d (P & F) 1484*; September 12, 1975, Argued, January 5, 1976

10. No. 75-1216. NATIONAL ASSOCIATION OF RADIOTELEPHONE SYSTEMS v. FEDERAL COMMUNICATIONS COMMISSION ET AL. SUPREME COURT OF THE UNITED STATES  
*425 U.S. 992*; *96 S. Ct. 2203*; *48 L. Ed. 2d 816*; *1976 U.S. LEXIS 419*, May 24, 1976, Reported below: *173 U.S. App. D.C. 413*, *Cert denied*.

11. In the Matter of Extension of Time Limit for Adoption of Rules and Technical Standards for Cellular Mobile Radio Communication Systems, Order, FCC 78-828, *70 FCC.2d 1639*. Adopted: November 30, 1978

CC Docket No. 79-318

In the Matter of An Inquiry Into the Use of the Bands 825-845 MHz and 870-890 MHz for Cellular Communications Systems; and Amendment of Parts 2 and 22 of the Commission's Rules Relative to Cellular Communications Systems

12. Notice of Inquiry and Notice of Proposed Rulemaking, *8 FCC.2d 984*, Adopted: November 29, 1979

13. Report and Order, *86 FCC.2d 46*, Adopted April 9, 1981

14. Memorandum Opinion and Order on Reconsideration, *89 FCC.2d 58*, Adopted February 25, 1982

General Docket No. 83-114

In the Matter of: A Re-Examination of Technical Regulations

15. Notice of Inquiry and Proposed Rulemaking, *48 FR 14399*, April 4, 1983.

16. Report and Order, *99 FCC.2d 903*, Adopted November 8, 1984

General Docket No. 84-1231

Additional Frequency Allocation for Cellular Systems

17. Notice of Proposed Rulemaking, *50 FR 3809*, January 28, 1985

18. Report and Order (combined with General Docket 84-1322, 84-1234), *2 FCC Rcd 1825*, Adopted July 24, 1986

General Docket No. 87-390

In the Matter of Amendment of Parts 2 and 22 of the Commission's Rules to Permit Liberalization of Technology and Auxiliary Service Offerings in the Domestic Public Cellular Radio Telecommunications Service

19. Notice of Proposed Rulemaking, *2 FCC Rcd 6244*, Adopted September 17, 1987
20. Report and Order, *3 FCC Rcd 7033*, Adopted October 13, 1988
21. Memorandum Opinion and Order, *5 FCC Rcd 1138*, Adopted February 15, 1990

General Docket No. 90-314

In the Matter of Amendment of the Commission's Rules to Establish New Personal Communications Services. (Note: Orders within this docket that address narrowband PCS are called out specifically by title)

22. Notice of Inquiry, *5 FCC Rcd 3995*, Adopted June 14, 1990
23. Policy Statement and Order, *6 FCC Rcd 6601*, Adopted October 24, 1991
24. Notice of Proposed Rulemaking and Tentative Decision, (includes ET Docket No 92-100), *7 FCC Rcd 5676*, Adopted July 16, 1992
25. Tentative Decision and Memorandum Opinion and Order, *7 FCC Rcd 7794*, Adopted October 8, 1992
26. In the Matter of Amendment of the Commission's Rules to Establish New Narrowband Personal Communications Services, First Report and Order, *8 FCC Rcd 7162*, Adopted June 24, 1993; As Corrected October 31, 1994
27. Second Report and Order, *8 FCC Rcd 7700*, Adopted September 23, 1993
28. Third Report and Order, *9 FCC Rcd 1337*, Adopted December 23, 1993; As Corrected March 14, 1994
29. In the Matter of Amendment of the Commission's Rules to Establish New Narrowband Personal Communications Services, Memorandum Opinion and Order, *9 FCC Rcd 1309*, Adopted February 3, 1994
30. Memorandum Opinion and Order, FCC 94-144, Adopted: June 9, 1994
31. Further Order on Reconsideration, *9 FCC Rcd 4441*, Adopted July 22, 1994
32. Second Memorandum Opinion and Order, *9 FCC Rcd 4519*, Adopted August 16, 1994
33. New Personal Communications Services; Pioneer's Preference Review (includes ET Docket No 93-266), FCC 94-209, Effective September 19, 1994
34. Third Memorandum Opinion and Order, *9 FCC Rcd 6908*, Adopted October 19, 1994
35. Memorandum Opinion and Order, *9 FCC Rcd 7805*, Adopted December 2, 1994
36. In the Matter of Amendment of the Commission's Rules to Establish New Personal Communications Services in the 2 GHz Band; Amendment of the Commission's Rules to Establish New Narrowband Personal Communications Services (includes ET Docket No 92-100), Memorandum Opinion and Order, *10 FCC Rcd 7893* Adopted March 2, 1995
37. Notice of Proposed Rulemaking, Order on Remand, and Waiver Order (includes WT Docket 96-162), FCC 96-319, Adopted July 25, 1996.

ET Docket No 92-9

In the Matter of Redevelopment of Spectrum to Encourage Innovation in the Use of New Telecommunications Technologies

- 38. Notice of Proposed Rulemaking, 7 *FCC Rcd* 1542, Adopted January 16, 1992
- 39. Further Notice of Proposed Rulemaking, 7 *FCC Rcd* 6100, Adopted August 5, 1992
- 40. First Report and Order and Third Notice of Proposed Rulemaking, 7 *FCC Rcd* 6886, Adopted September 17, 1992;
- 41. Second Report and Order, 8 *FCC Rcd* 6495 , Adopted July 15, 1993
- 42. Third Report and Order and Memorandum Opinion and Order, 8 *FCC Rcd* 6589, Adopted July 15, 1993
- 43. Memorandum Opinion and Order, 9 *FCC Rcd* 1943, Adopted March 8, 1994

ET Docket 92-100

In the Matter of Amendment of the Commission's Rules to Establish New Personal Communications Services

- 44. Notice of Proposed Rulemaking and Tentative Decision, 7 *FCC Rcd* 5676, Adopted July 16, 1992
- 45. First Report and Order, FCC 93-329, Adopted June 24, 1993
- 46. Memorandum Opinion and Order, FCC 94-30, Adopted Feb 3, 1994
- 47. Report and Order and Further Notice of Proposed Rulemaking, FCC 97-140, Adopted April 17, 1997

PP Docket No. 93-253

In the Matter of Implementation of Section 309(j) of the Communications Act - Competitive Bidding

- 48. Notice of Proposed Rulemaking, 8 *FCC Rcd* 7635; FCC 93-455, Adopted Sept 23, 1993.
- 49. First Report and Order, FCC 94-32, Released Feb 4, 1994
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- 52. Fourth Report and Order, 9 *FCC Rcd* 2330 (1994)
- 53. Fifth Report and Order, FCC 94-178; 59 FR 37566, released July 15, 1994
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67. Seventh Report, FCC 02-179, Adopted Jun 13, 2002
68. Eighth Report, FCC 03-150, Adopted Jun 26, 2003
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